

**University of Hawaii**

**Final Technical Report**

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**"1999 Bioastronomy Meeting"**

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**Submitted by**

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# Final Report – “1999 Bioastronomy Meeting”

## 1 Executive Summary

The 6th Bioastronomy Conference, Bioastronomy '99: A New Era in Bioastronomy, was held at the Hapuna Prince Beach hotel on the Big Island of Hawaii from August 2-6, 1999. The series of previous Bioastronomy meetings have played an important role in integrating the broader interests and techniques of both astronomy and biology to understand the origin and evolution of living systems in the universe, and to generating a context for exploration in our solar system and in extrasolar planetary systems. The scope of these interdisciplinary fields is captured in the topics discussed at the meeting: organic molecules in interstellar and interplanetary space; origin and evolution of planetary systems; comets, asteroids, and other small bodies and their role in the origin and evolution of life; Earth as a living planet; extreme environments on Earth; origin of life; transport of life between planets; evolution of life and intelligence; detection and characterization of extrasolar planets; search for extraterrestrial technology and life; future missions; and public acceptance and support of scientific studies of life in the universe. The papers presented at the meeting have been published in the *Astronomical Society of the Pacific Conference Series Vol 213*, Ed. G. Lemarchand and K. J. Meech.

## 2 Introduction

The 1999 Bioastronomy meeting was the sixth in a series of international conferences on this topic initiated by the International Astronomical Union (IAU) Commission 51. Lemarchand (2000; this volume) describes the origin of this field and the history of the previous Bioastronomy meetings. The venue for the meeting was approved at the IAU General Assembly in Kyoto, Japan, in 1997 August, with John Rummel (NASA HQ) as the Scientific Organizing Committee chair and Karen Meech (UH, Institute for Astronomy (IfA)) as the Local Organizing Committee chair. Table 1 lists the committee members.

The meeting was held at the Hapuna Prince Beach Hotel from August 2-6, 1999 on the big island of Hawaii. At the meeting we had 192 registrants (including 17 students and 6 members of the press), with 144 accepted papers in total. Of these, 77 papers were oral and there were 67 poster papers. One hundred two papers have been written up and included in this volume. The format of the meeting was designed to create extensive cross-disciplinary discussions. To this end, we had a large number of invited oral papers (40% of the oral contributions), some contributed oral papers, and dedicated poster sessions.

Table 1: Bioastronomy '99 Committee Members.

Local Committee / Affiliation	Science Committee / Affiliation
Karen Meech (USA)	John Rummel (USA)
Luann Becker (USA)	David Morrison (USA)
Klaus Keil (USA)	Stuart Bowyer (USA)
Jon Lomberg (USA)	Cristiano Cosmovici (Italy)
Narayan Raja (USA)	Jim Kasting (USA)
Tobias Owen (USA)	Masatoshi Ohishi (Japan)
Jeff Taylor (USA)	Tobias Owen (USA)
Karen Teramura (USA)	Didier Queloz (USA)
Alan Tokunaga (USA)	Francois Raulin (France)
	Jill Tarter (USA)
	Harley Thronson (USA)
	Guillermo Lemarchand (Argentina)

The conference was held on the Kohala coastline of the big island of Hawaii because of its proximity to the Mauna Kea Observatories and the active Kilauea volcano – both areas of significant interest to the participants. The Hapuna Beach Prince Hotel conference center was arranged around a large central courtyard, and consisted of a large ballroom where we held the plenary sessions, and a smaller ballroom for the posters, in addition to 6 additional breakout rooms for our computer center, pre-workshop meetings and educational workshop. The courtyard was a focal point for informal discussion during breaks. In addition to the scientific sessions, there were several social functions associated with the conference. The conference opened on Sunday evening, August 1, with an informal heavy “pupu” reception, which served as dinner. Because of the hotel’s isolation, the LOC arranged for pleasant buffet lunches to be served daily in the Coast Grille restaurant, overlooking the ocean. Posters were displayed during two 2.5-day sessions, and for each session we hosted late afternoon refreshments which helped to stimulate lively discussions.

### 3 Education Workshop

On August 4, we had a half day of scientific sessions to allow meeting attendees to participate in several tours. In addition, on this day we also had a special educational symposium “Astro + Biology” = *Astrobiology 1999* for 50 local kindergarten through 12th grade teachers. This symposium gave the teachers the opportunity to interact with scientists via keynote speakers, panel presentations and informal conversations. We had several hands-on sessions featuring successful astrobiology classroom activities. This program gave teachers a unique opportunity to see first-hand what the educational outreach efforts are in astrobiology, with topics including: microbes in extreme environments, discussion of deep sea vents, planetary origins, searching for signs of life on other planets, and responsibilities for protecting new planets. The scientific participants in the program included: John Rummel, David Morrison, Bruce Jakosky, Rose Grymes and Karen Meech. This portion of the program was sponsored by the NASA Life Sciences Outreach Program and the NASA Astrobiology Institute Outreach Office.

### 4 Secondary Scientific Activities

Prior to the meeting, the Foundation for the Future hosted a focused discussion group on the cultural impact of extraterrestrial contact. Given that a dialogue with another civilization is believed to be a reasonably likely event in the next 1000 years, the focus of the group was to discuss the impact this contact would have on our civilization. Billingham (2000; *Bioastronomy 1999 Proceedings*) summarizes the results of this pre-meeting workshop.

During *Bioastronomy '99* two scientific tours were offered: an inside tour of the Mauna Kea Observatories and a scientific Volcano Tour. The tour of Mauna Kea allowed participants to get an inside view of some of the telescope facilities on Mauna Kea, including the Keck and NASA Infrared Telescope Facilities. These tours were lead by Alan Tokunaga (Univ. Hawaii, Institute for Astronomy). The two-day volcano tour was targeted at those meeting participants who wanted to gain a scientific understanding of the geology and history of the Hawaiian volcanos and how they relate to volcanism in the solar system, and was lead by Jeff Taylor (Univ. of Hawaii, Hawaii Institute of Geophysics and Planetology planetary volcanologist). Highlights included seeing live lava from on top of a lava tube and a visit to the University of Hawaii–Caltech drill hole project. The drill-hole project seeks to understand Hawaiian volcano evolution, including lava composition, its chemical evolution when mixed with seawater, the rate of subsidence of the land mass and a search for water resources. During the drilling, which has extended to a depth of 10,000 feet, possible unusual biological remains have been brought up. So far it is not known if these represent current biosystems or remains from earlier periods.

## 5 Conference Arrangements

The LOC was responsible for all the meeting arrangements, including the design, production and mailing of all announcements, receipt or abstracts and printing of abstract books, conference registration, tours and venue selection. Because Hawaii is a high cost destination, the LOC saved funds by not outsourcing any of these tasks and producing everything in-house. This resulted in being able to keep the registration fees reasonable. It is estimated that the workload prior to the meeting was approximately 1000 hours, all volunteer. A decision was made to do as much as possible on-line through the web. Abstracts were submitted through a secure website in ascii (or LaTeX) and converted automatically to LaTeX for typesetting. The SOC conducted its review and selection of papers entirely online through this web site. While this worked well, and enabled us to provide an outstanding meeting for the participants, there were several lessons learned which will be useful for future meeting planners:

- Outsource the online registration and abstract receipt – the time requirements are large
- Require that all travel award winners publish their papers
- Charge a page charge to the participants for the preparation of the conference proceedings. Although camera ready papers were required to be submitted by 15 October 1999, in either MS Word or LaTeX formats, less than 30% of the papers were submitted on time, and the last of the papers was not completed (revised) until 2000 August, delaying the publication by ~8 months. We spent approximately 1200 hours working on the final “production” of the camera ready documents.

The meeting would not have been possible without the generous support from a large number of sponsors. Table 2 lists the sponsors and their contributions.

Table 2: Bioastronomy '99 Sponsors.

Sponsor	Amount	Contribution
NASA GSFC	\$40,000	Travel Grants
Jet Propulsion Laboratory	\$20,000	Meeting Support
NASA HQ	\$14,500	Proceedings Publication
NASA Ames	\$10,000	Meeting Support
The SETI Institute	\$10,000	General Support
NASA Life Sciences Program & NASA Astrobiology Institute Outreach	\$ 7,750	Educational Workshop
Lockheed Martin	\$ 1,000	Meeting Support
NASA Integrated Services Network	in kind	Internet access
Institute for Astronomy	in kind	Staffing support
Paradise Safaris	in kind	Mauna Kea Tours
International Academy of Astronautics	in kind	Advertisement

We received a significant amount of travel support for this meeting. A total of 31 travel grants were given out for participants to attend the meeting. The grants ranged anywhere from \$250 to \$2,550. The main criteria was financial need, however in order to receive a grant the applicant must have had an accepted abstract at the meeting.

## 6 Science Content of the Meeting

### 6.1 Pre-Solar Nebula and Planet Formation

The existence of life relies upon the proper chemical foundations, and there were several intriguing talks on the origins and evolution of pre-biotic organic materials. Many of the organic molecules which gave rise to life on Earth originated in space and were probably brought here from cometary impacts, as discussed by both John Oró, Akiva Bar-Nun and Tobias Owen. Continued laboratory studies of ices have shown that the deuterium enrichment seen in Earth's atmosphere over the expected solar value is probably a result of enrichment in the molecular clouds and subsequent cometary transport to Earth. The impact delivery survivability of large organic molecules, however, has been questioned because of the high impact temperatures and pressures. University of Hawaii geochemist Luann Becker reported the exciting discovery of large fullerene carbon molecules in the 1.85 Gy Sudbury Crater and in K/T impact clay sediments. Their presence suggests that impacts can bring pre-biotic molecules to Earth.

Oró illustrated how these organics arriving from comets and present in meteorites could then chemically synthesize the most important pre-biotic biochemical compounds on Earth. This was followed by several talks discussing how the raw interstellar materials evolved into planetary systems, paying special attention to how our current ideas of planetary formation have changed with the discovery of extrasolar planets. In addition, the group was kept current on our understanding of the characteristics and evolution of the relics of this formation process, Kuiper Belt Objects, comets and asteroids, and upcoming space missions focussing on these small bodies.

### 6.2 Life Possibilities in our Solar System

After a presentations on the essential life materials, the attention focussed on life habitats in extreme environments, and possible habitable zones within our solar system. A discussion of what the biosignatures of life might be by Jack Farmer, lead into a renewed discussion of the ALH84001 Mars meteorite life issues by A. Treiman.

James Head (Brown University) presented a fascinating look at the Mars Global Surveyor (MGS) laser altimeter data which revealed evidence supporting the presence of large standing bodies of water on the scale of oceans on Mars, although more recent MGS press releases call these conclusions into question. Continued images should help resolve this exciting possibility. Head also discussed the Galileo data which supported past global oceans on Ganymede and the ocean which may presently exist on Europa.

The existence of oceans is exciting because of the likely prospect that terrestrial life began in the vicinity of hydrothermal vent systems which were similar to those in our oceans today. Rodey Batiza (Univ. HI), suggested that most currently known fundamental submarine volcanic geophysical processes are probably similar to those on the early Earth since volcanism is driven by heat lost from the interior, and the same processes may be present on outer solar system satellites. Dave Karl, an oceanographer at the University of Hawaii, then discussed selected extreme environments on Earth (hydrothermal vents and deep sub-glacial Antarctic lakes), focussing on the physical adaptations and physiological tolerances which have evolved in microorganisms surviving at the limits of life in extreme environments.

One of the concerns surrounding the possibility of the evolution of life in the possible subsurface oceans of the Jovian satellites is the energy source for the organisms. Cindy Van Dover from the College of William and Mary explored this idea by presenting exciting results on a terrestrial species of deep water vent shrimp which have evolved to see the near infrared light emitted from the vents suggesting that the vents may support geothermally driven photosynthesis.

### 6.3 Origins of Life

In a half day session dedicated to the more purely biological aspects of bioastronomy, several interesting talks were given. Jeremy Bailey discussed the origin of the homochirality of biological molecules and

related this to the polarization environment of the region in which the star formed. In a series of talks, David Des Marais (Ames Research Center), J. William Schopf (University of California) and Simon Conway Morris (University of Cambridge) discussed how life interacts with the biosphere, shaping it and being shaped by it, and whether or not the form of life is closely linked to the specific environment of this planet, or whether life converges to some common themes. If so, the implications would be that life in other environments on other worlds might not be so different.

## 6.4 New Extrasolar Planetary Systems

In 1996 one of the Bioastronomy conference highlights was the report of the discovery of extrasolar planets. The field has matured significantly, and Paul Butler, working with Geoff Marcy, reported that Doppler measurements of 500 main sequence stars have now found 20 Jupiter-sized companions. Data is now sufficient to begin to characterize these planetary systems (down to a mass limit of  $0.5 M_{Jup}$ ), showing planets in circular orbits inside of 0.1 AU ("hot Jupiters") and planets in highly eccentric orbits, suggesting that regular planetary systems like our own may not be typical. To date, all of the detected planetary systems have been found around stars which are enriched in heavy elements, which indicates that this enrichment may be a key factor in planet formation.

An exciting array of new missions in progress and proposed missions was presented, aimed at both detecting lower mass planets and to begin to characterize their physical properties. Among the different techniques discussed was a method using eclipsing binary stars to provide sensitive limits on the existence of planets as small as  $2.5 R_{Earth}$  in the habitable zone by Laurance Doyle of the SETI Institute. Current observations of young planetary disk systems using the NICMOS infrared camera on the Hubble Space Telescope were presented by Brad Smith (Univ. HI). Plans for the CNES/ESA COROT spaceborne imaging photometer to make sensitive detections using transit photometry on 50,000 stars were discussed, as was the NASA Terrestrial Planet Finder program which should start in 2007 and launch in 2011. This spaceborne interferometer should be able to detect planetary systems out to 50 light years, and determine the size, temperature and orbits of terrestrial planets in the habitable zones as well as search for biologically significant atmospheric gases.

## 6.5 The Forefront of SETI

Unfortunately, there were no reports of detected intelligent extraterrestrial signals at this conference, however, there were excellent progress reports from several ongoing programs, and some inroads into new search areas. One particularly ingenious new search technique involves utilizing an enormous distributed computer network across the internet. David Anderson reported on the SETI@home program which began in the spring of 1999, using the desktop computers of a multitude of volunteers. As of August 2000, there were 2.2 million users (and this number grows rapidly each day) from over 225 countries. The network has so far devoted nearly 250,000 years of cpu time to the project using computers in homes, schools and in the workplace.

D. Leigh, S. Bowyer, D. Werthimer, G. Lemarchand, and K. Cullers reported on the status of several long-running SETI searches which have been expanding since the 1996 meeting. Optical SETI, which searches for a high-intensity pulsed laser signal which would be visible over large distances, is beginning its operations at Harvard. In even more forward-looking endeavors, UC Berkeley and the SETI Institute have begun a project to build a large array which will operate in the 1-10 GHz range and have a total collecting area of 1 hectare. This instrument will be the largest in the world, and the first one dedicated to SETI. In a final look into the future of SETI, Jill Tarter reported on a concept for the square kilometer array (SKA) which could be built by an international consortium. The telescope, which would have a collecting area of 1 million square meters, and would be at the forefront of the entire bioastronomy field. With superb sensitivities, and a resolution comparable to the Hubble Space Telescope, the array could look at the evolution of biogenic elements, map the evolution of protoplanetary disks and search for planets, including those inhabited by advanced technologies.

This portion of the meeting was sponsored by the SETI Institute.

## 7 Publications

### 7.1 Refereed Publications

- [1] Meech, K. J. (2000). "Bioastronomy '99 – Meeting Overview", in *Bioastronomy '99 – A New Era in Bioastronomy*, Proceedings of a Conference held on the Kohala Coast, Hawaii 2-6 Aug 1999, ASP Conf. Ser **213**, 23-34.
- [2] Meech, K. J. (2000). "Cometary Origin and Evolution", in *Bioastronomy '99 – A New Era in Bioastronomy*, Proceedings of a Conference held on the Kohala Coast, Hawaii 2-6 Aug 1999, ASP Conf. Ser **213**, 207-216.
- [3] Meech, K. J. *et al.* (2000). "Deep Impact, Exploring the Interior of a Comet", in *Bioastronomy '99 – A New Era in Bioastronomy*, Proceedings of a Conference held on the Kohala Coast, Hawaii 2-6 Aug 1999, ASP Conf. Ser **213**, 235-242.
- [4] Meech, K. J., T. F. Slater, J. A. Mattei and M. A. Kadooka (2000). "A Pacific Teacher Enhancement Program – Toward Other Planetary Systems", in *Bioastronomy '99 – A New Era in Bioastronomy*, Proceedings of a Conference held on the Kohala Coast, Hawaii 2-6 Aug 1999, ASP Conf. Ser **213**, 679-684.

